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RIVULARIELLA, GEN. NOV. (JUNGERMANNIACEAE), ENDEMIC TO WESTERN NORTH AMERICA

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ABSTRACT

Rivulariella gemmipara (A.W. Evans) D.H. Wagner is a rare hepatic species known from Alaska, Oregon, California, and Utah. Originally described in the genus *Chiloscyphus*, it is here recognized as a new, monotypic, endemic genus in the Jungermanniaceae (Marchantiophyta).

KEY WORDS: Jungermanniaceae, *Chiloscyphus*, *Rivulariella*, aquatic, endemic, Alaska, Oregon, California, Utah.

Chiloscyphus gemmiparus A.W. Evans was described from a hepatic specimen gathered near Spirit Lake in the Uinta Mountains, Utah (Evans 1938). For many years it was known only from the type collection. The original collection was sterile and Evans' placement of the plants in *Chiloscyphus* was not explained beyond his comment that "it bears a certain superficial resemblance" to the two species known in this genus, "both of which grow in more or less aquatic habitats."

Further attention to this species has been sparse. Frye and Clark (1943, p. 249) merely copied the text and illustrations from Evans. Flowers (1950) mentioned the plant, again simply citing Evans' work. Schuster (1980) very briefly referred to it as "poorly known," the only member of the genus (*Chiloscyphus*) with gemmae. Hong's treatment of the Geocalycaceae in Western North America stated only that material of this taxon was not available for study (Hong 1993). Doyle and Stotler (2006) did not mention the species in their keys to the liverworts of California.

In 1981, I found an aquatic liverwort in the inlet stream to South Lake, Seven Lakes Basin, Jackson County, Oregon. The nature of the gemmae, leaf cells, and underleaves matched the description of *Chiloscyphus gemmiparus* well enough that identity seemed likely. I borrowed the type and concluded by comparison that the Oregon population belonged to the same taxon. I determined the species was monoicous, had long, nearly isophyllous, sexual shoots, and scattered rhizoids. Because of the scattered instead of fascicled rhizoids, I knew the species should not be placed in *Chiloscyphus*, not even the Geocalycaceae, but did not have sufficient data to propose a suitable generic or family placement.

In August, 1984, I found the same plant in a small stream near Mesa Creek in the Three Sisters Wilderness, Oregon. Despite adding to an appreciation of the vegetative plasticity of this species, this material still lacked critical reproductive features. A single, immature perianth indicated that the locality could possibly yield suitable material if visited later in the season.

At the end of September, 1985, the Mesa Creek population was revisited. Plants were found growing out of the water onto the shady side of boulders. Perianths and mature sporophytes were present. This material, with plicate perianths, indicated placement in the Jungermanniaceae. The shallowly bilobed leaves, frequent presence of underleaves, production of gemmae, and habitat are the basis for describing it as a new genus endemic to western North America. It is presently known from four states: Alaska, California, Oregon, and Utah. Only in Oregon is there more than one record.

RIVULARIELLA D.H. Wagner, gen. nov. **Figs. 1–6.** **TYPE**: *Rivulariella gemmipara* (A. Evans) D.H. Wagner

Plantae aquaticae, quoad staturam mediocres, usque ad 30 mm longae, 4mm latae. Caules leviter vel valde compressi; rhizoidea adsparsa, in caulibus prostratis abundantia, in ascendentibus nulla. Folia lateralia variabilia, succuba, 120-150 x 150-200 mm, oblique vel transversim inserta, obovata, truncata, emarginata vel breviter bilobata; parietes cellulorum tenues, trigonis nullis vel parum evolutis; guttae olei 5-13 (raro 20+) per cellulam foliarem medianam. Amphigastria nulla vel fugacia, ad caules prostratos sita, parva subulataque vel ad caules adscendentes grandia et lanceolata; caules erecti fere isophylla. Reproductio vegetativa per gemmas 2-6, ad apicem caulis secus margines folii efficientes. Monoicae: paroicae vel heteroicae. Androecia spicata vel non spicata. Gynoecia terminalia; perianthium supra bracteas usque 1/2 longitudinis sui exsertum, inflatum, oblongum vel fusiforme, infra cylindricum, distaliter 4-5-plicatum, in os integrum vel leniter crenulatum angustatum; perigynium nullum.

Rivulariella gemmipera (A. Evans) D.H. Wagner, comb. nov. *Chiloscyphus gemmiparus* A. Evans. Bryologist 41: 50. 1938. **TYPE**: **UTAH.** Summit Co. (Daggett Co.?): Uinta Mountains, Ashley National Forest, Spirit Lake, near timberline, [40° 50′ 28″ N, 109° 59′ 54″ W, 3100 m], 18 August, 1928, *A. Svihla 476* (holotype: YU!).

Plants medium sized, shoots to 30 mm long and 4 mm wide, prostrate to ascending, dark green, blackish at base, attached to small rocks and pebbles in moving water. **Stems** slightly to strongly dorsiventrally compressed; prostrate stems flattened, 450 µm wide, 200 µm high; stems of ascending shoots are more nearly cylindrical, to 400 µm in diameter; branches mainly lateral-intercalary on prostrate shoots, often abundant; branches sparse on ascending shoots, mainly terminal type; cortical cell walls thin, 15 × 29 µm, medullary cells 30 × 40 µm with slightly thicker cell walls; rhizoids scattered, abundant on prostrate stems, absent on ascending stems. **Lateral leaves** variable, succubous, 120–150 × 150–200 mm, inserted obliquely and spreading on prostrate shoots, nearly transverse, imbricate and concave on ascending shoots, obovate, rounded or truncate to emarginate or shallowly bilobed. **Median cells** subquadrate to elongate-rectangular, rarely hexagonal, 16–18 × 17–25 µm, cell walls thin, trigones absent or poorly developed, marginal cells slightly smaller, cuticle smooth. **Oil-bodies** average 5–13 (rarely 20+) per median leaf cell, ovoid, 4 × 6 µm, finely granular, colorless. **Underleaves** absent or fugacious on prostrate stems, usually small, few celled and multilobed or subulate to lanceolate on ascending stems, with larger underleaves occurring sporadically and randomly, occasionally nearly the same size and shape as the lateral leaves on erect shoots, these shoots virtually isophyllous. **Asexual reproduction** by fasciculate gemmae produced along leaf margins at shoot tips, abundant in some populations but nearly absent in others; ovoid at maturity, 120–180 × 160–300 µm, typically composed of 2–4 cells each. **Sexual condition** monoicous: paroicous or heteroicous. **Androecia** either below gynoecia or on separate shoots, antheridia 2–3 per bract, in bracteoles of isophyllous shoots on paroicous shoots or in bracts little different from vegetative leaves on anisophyllous shoots when strictly male, spicate or not. **Gynoecia** terminal on erect, isophyllous shoots, bracts and bracteoles broader than leaves, archegonia developing before perianth formation, perianth exerted 1/2 or more above bracts, inflated, oblong to fusiform, smooth cylindrical below, 4–5 plicate distally, narrowed to an entire or weakly crenulate mouth; perigynium absent. **Sporophyte** seta massive, many cells thick; capsule wall several cell layers thick, only the outer layer having nodular thickening and the inner cells with semiannular thickenings. **Spores** noticeably green when fresh. **Elaters** mostly bispiral, but trispiral elaters frequent

Additional specimens examined: **Alaska**. Aleutian Islands, Unalaska Island. Unalaska River south of Unalaska, [53° 49′ 38″ N, 165° 30′ 9″ W], ca. 1000 feet/305 m, 12 Jul 1967, *Z. Iwatsuki, A.H. & E. Sharp 1581* (OSC). **California**. Sierra Co.: Yuba Pass Road, 3-4 mi S of Yuba Pass, 39° 34′ N, 120° 29′ W, 1830 m, 6 Jun 1987, *B. Thiers 5403a* (OSC). **Oregon**. Deschutes Co.: Three Sisters Wilderness, between Goose Creek and Fall Creek, 44° 2′ 18″ N, 121° 44′ 6″ W, 1712 m, 7 Aug 2012, *R. Dewey 080712-1036* (OSC); Three Sisters Wilderness, tributary to Fall Creek, 44° 3′ 43″ N, 121° 44′ 25″ W, 1840 m, 4 Sep 2006, *D. Kofranek 2493* (OSC). Jackson Co.: Inlet stream, South Lake. 42° 39′ 01″ N, 122° 13′ 27″ W, 1850m, 7 Aug 1981, *D.H. Wagner 2747, 2750* (OSC); North Fork of South Fork, Little Butte Creek, 42° 22′ 45″ N, 122° 21″ 48″ W, 1380 m, 20 Aug 1999, *W. Rolle* WR037 (OSC). Josephine Co.: Siskiyou Mountains, Hinkle Lake. 42° 1′ 1″ N, 123° 17′ 25″ W, 1710 m, 5 Aug 2009, *C.J. Emerson* CJE1113 (OSC). Lane Co.: Three Sisters Wilderness, stream between Rock Mesa and Mesa Creek, 44° 4′ 18″ N, 121° 49′ 4″ W, 1840m, 26 Aug 1984 *D.H.Wagner 3429,* 28 Sep 1985, *D.H. Wagner 3543,* 22 Sep 2005, *D.H. Wagner m1769* (OSC); Three Sisters Wilderness, stream below Eileen Lake, 44° 8′ 19″ N, 121° 50′ 52″ W, 5774ft/1760m, 12 Sep 2001, *D.H. Wagner m0860* (OSC); Three Sisters Wilderness, SE corner of Linton Meadows, 44° 7′ 15″ N, 121° 44′ 36″ W, 1830m, 12 Sep 2001, *D.H. Wagner m0848* (OSC); Three Sisters Wilderness, small stream on E side of Linton Meadows, 44° 7′ 52″ N, 121° 49′ 32″ W, 1830m, 12 Sep 2001 *D.H. Wagner m0863* (OSC).

Morphology

There is a dramatic difference in stem morphology depending whether the shoot is creeping or ascending. In general, the spreading, sprawling shoots are most flattened, and the ascending shoots less so. Dense rhizoids are found on horizontal portions of the stem, where it is attached to the substrate, rocks or pebbles. These stems may turn upwards and assume the morphology of ascending shoots with less flattened stems. Ascending shoots mostly lack rhizoids, and on these small underleaves may be easily demonstrated. However, sporadically yet regularly, without any predictability (association with branching or change in orientation from erect to horizontal shoots), are found large, usually lanceolate, underleaves nearly half the size of the lateral leaves. Despite their infrequent occurrence, they will be soon noticed in an ample collection because of their size.

Subfloral innovations are frequent. These are not as prolific on the emergent shoots bearing perianths and sporophytes but are regularly produced on shoots which have sex organs under water and do not get fertilized.

A diagnostic feature of *Rivulariella* is the presence of fasciculate, multicellular gemmae. Evans, lacking other characters, discussed the gemmae at length. They are typically 4-celled, the cells of the gemmae nearly twice as large as the leaf cells. Reproduction in this aquatic is likely mainly due to gemmae. It is worth noting that when the plants were collected from the Three Sisters Wilderness in August, 1984, abundant gemmae were found but when collected in late September, 1985, gemmae were scarce. Collections from Jackson County with abundant gemmae were made in early August. The Utah collection was made in mid August.

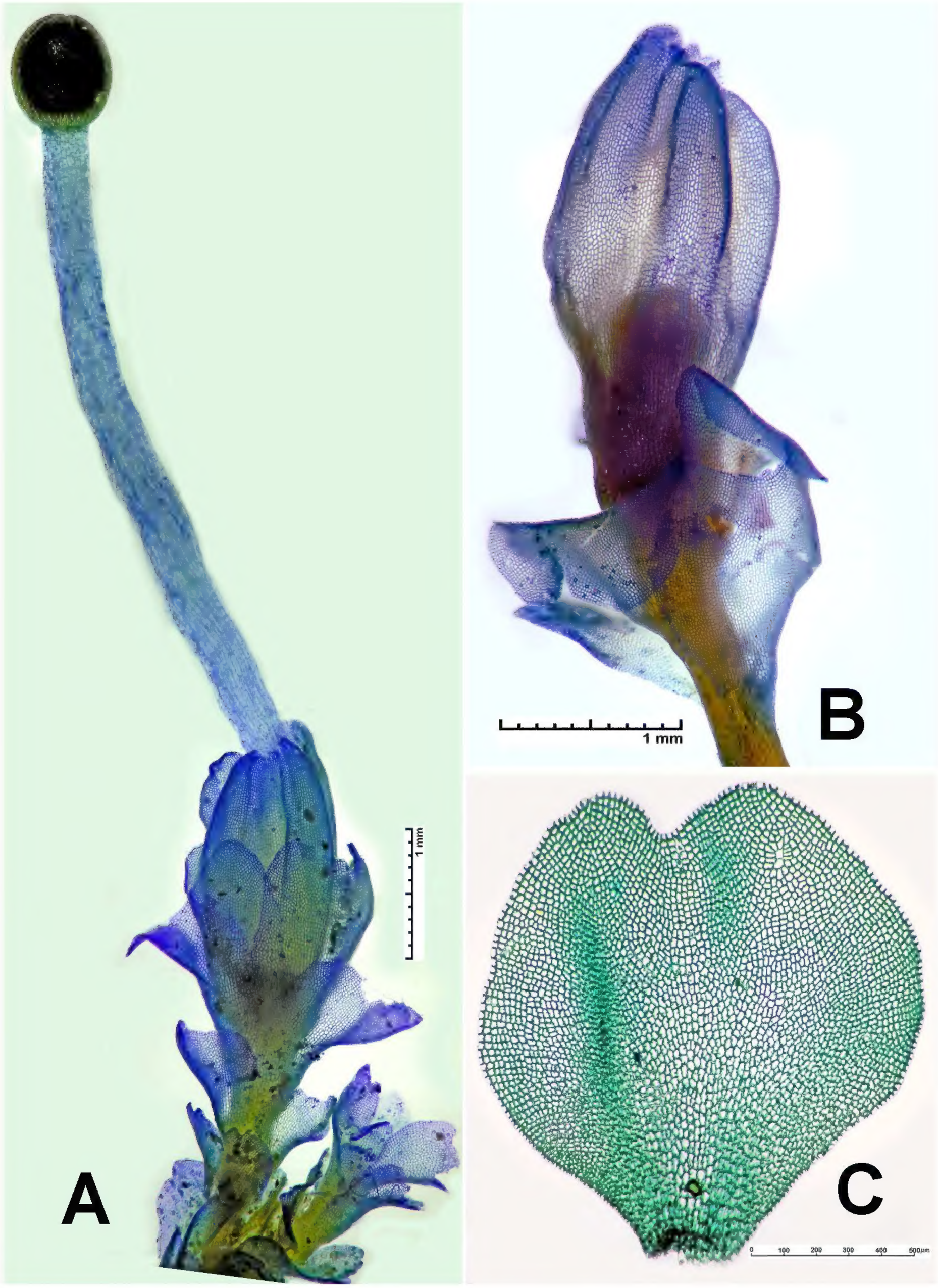

Figure 1. *Rivulariella gemmipara*. A. Gynoecium and sporophyte; B. gynoecium with very young sporophyte; C. female bract. (A–C, *D.H. Wagner 3543*).

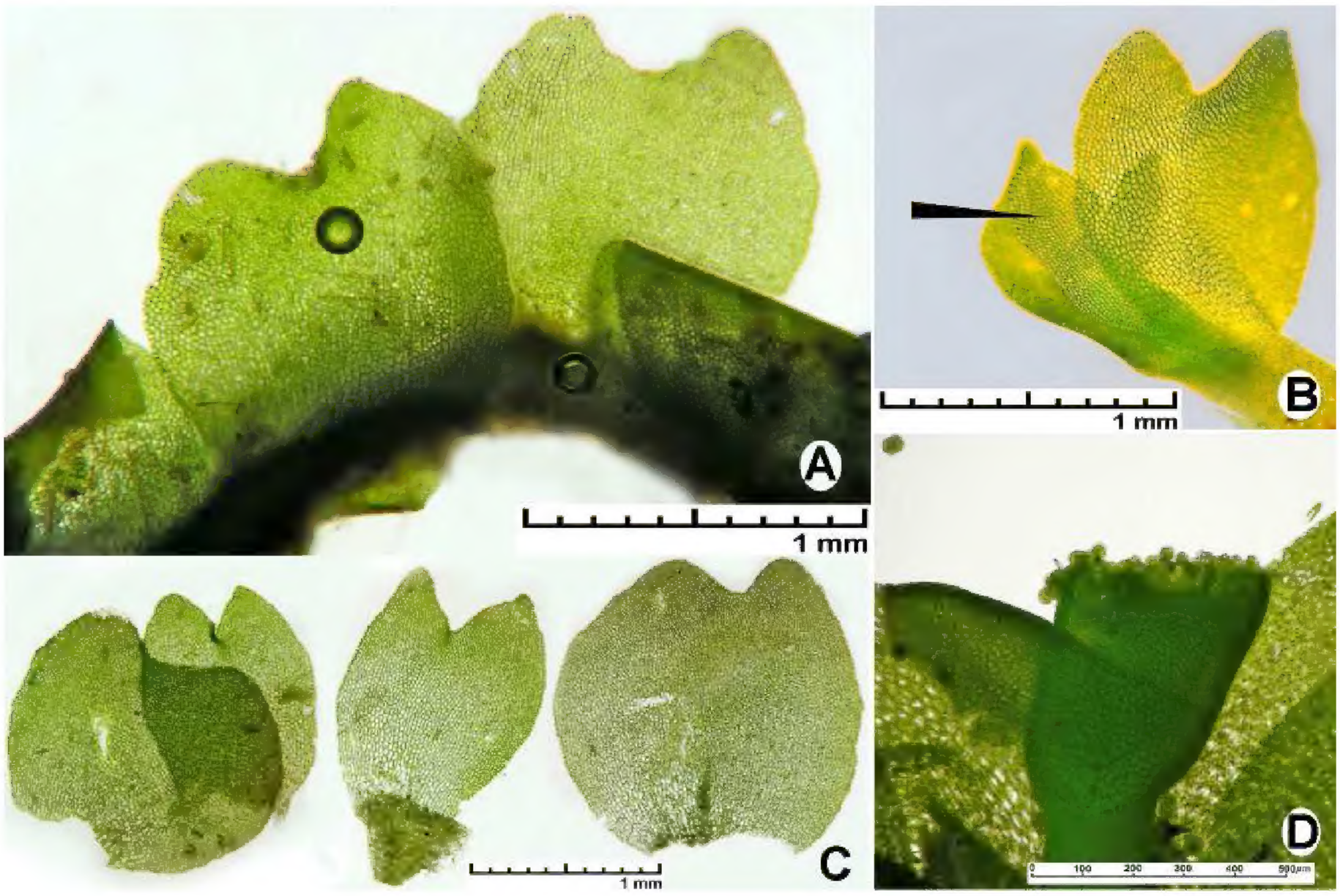

Figure 2. *Rivulariella gemmipara*. A. Horizontal shot; B. tip of horizontal shoot, large underleaf indicated by pointer; C. four leaves; D. shoot tip with gemmae. (A–D, *D.H. Wagner m1769*).

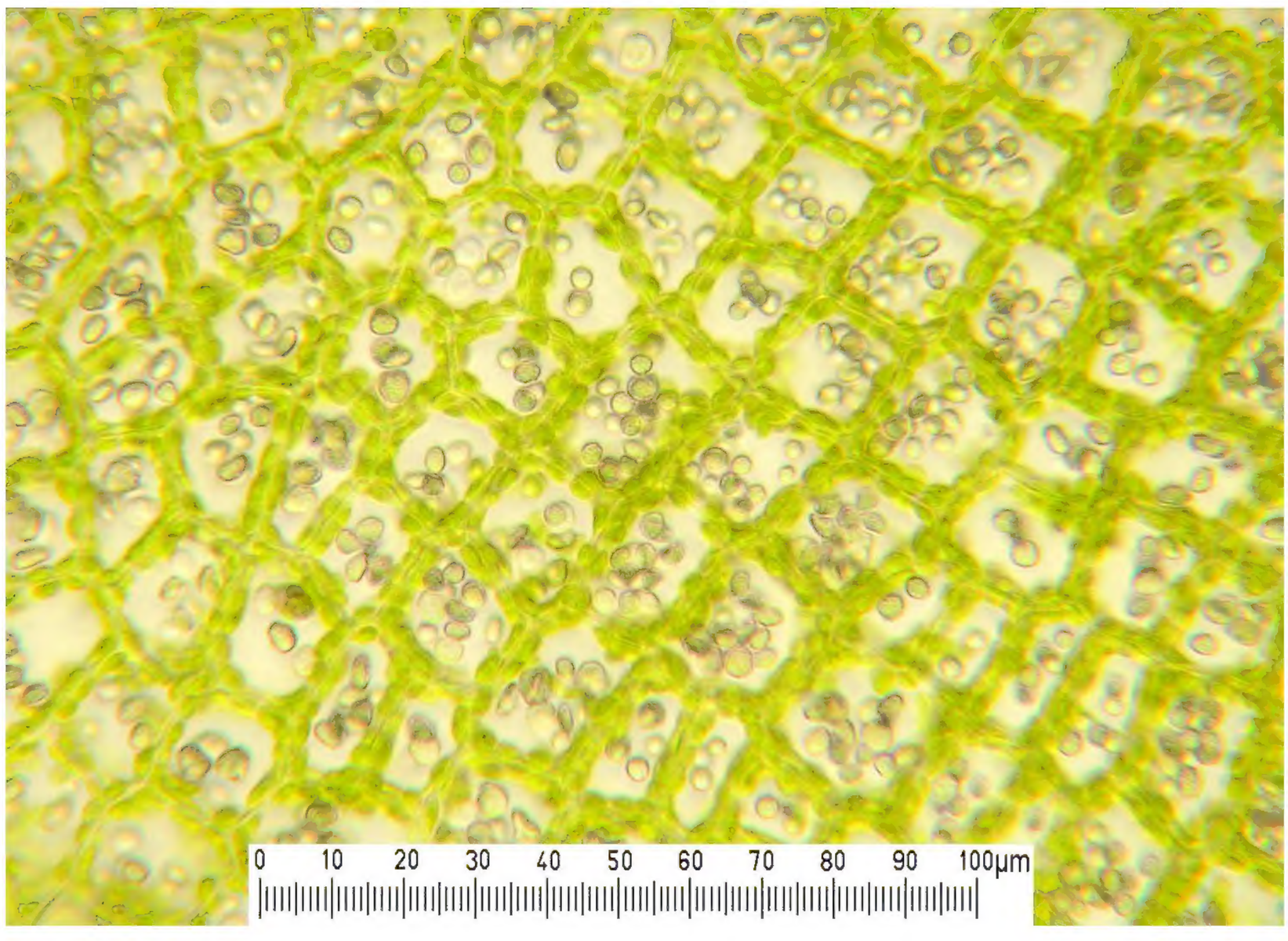

Figure 3. *Rivulariella gemmipara*. Oil-bodies in median cells. (*D.H. Wagner m1769*).

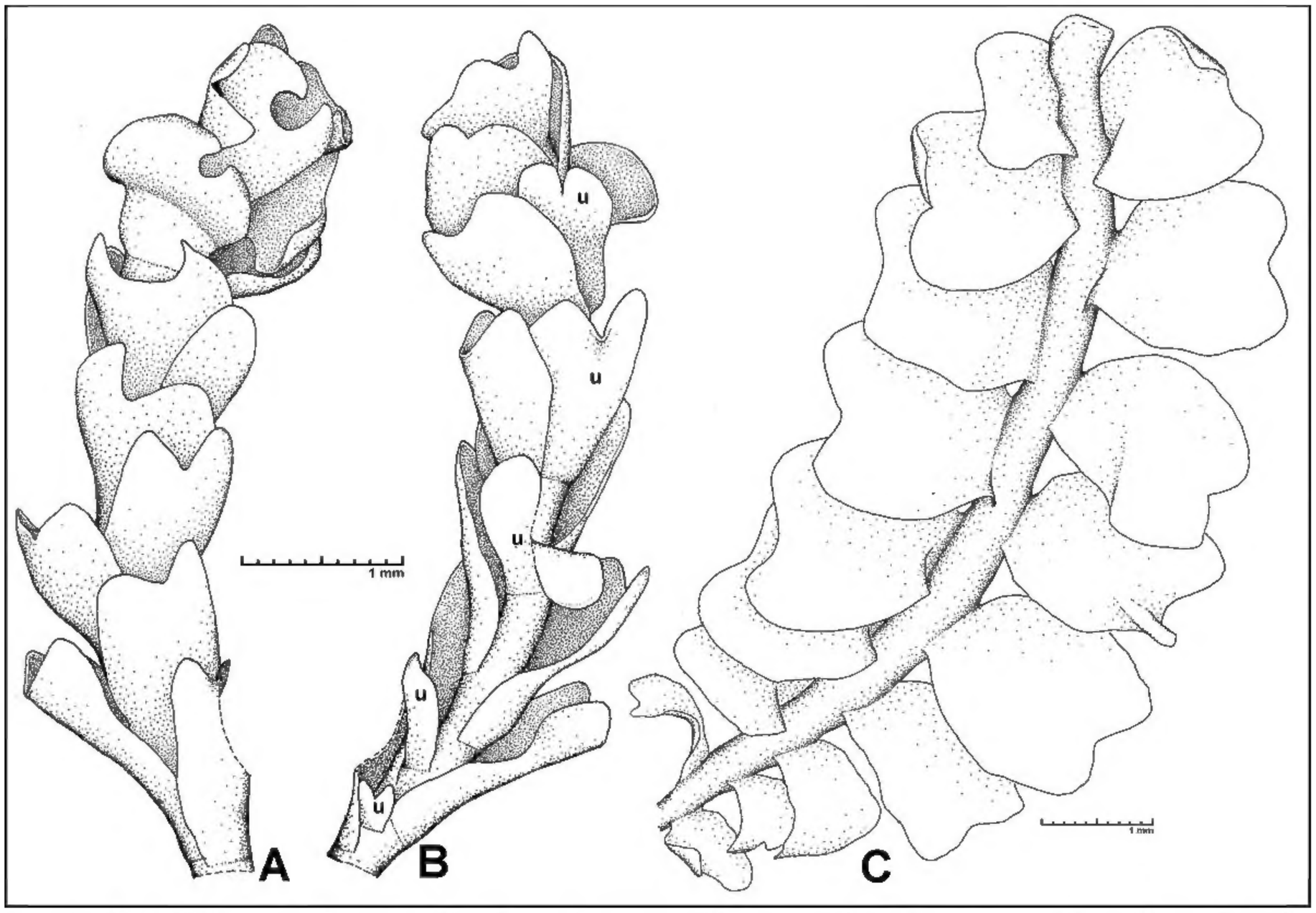

Figure 4. *Rivulariella gemmipara.* A. Erect, paroicous shoot in dorsal view; B. same shoot as A in ventral view with underleaves indicated by "u"; C. horizontal shoot. (A–C, *D.H. Wagner 2747*).

Male shoots are often found as subfloral innovations, produced below unfertilized archegonia. *Rivulariella* is heteroicous, exemplified in the fertile material collected in 1985. In this population were paroicous shoots, strictly male shoots, and strictly female shoots. Shoots with mature perianths and sporophytes seem to lack antheridia in the leaves below the perianths (in contrast to paroicous shoots of submerged plants). These may have male subfloral innovations which are anisophyllous. Most shoots bearing archegonia are nearly isophyllous, with large underleaves down the shoot below the bracteole. Male shoots have only small underleaves. Male bracts typically have two or three antheridia. Androecia are usually not spicate, but this also varies even along the same shoot. A male shoot may be in part spicate, with antheridial bracts reduced and closely imbricate, but further up the same shoot male bracts look like normal leaves except for a gibbous base.

Differentiation

The only plants likely to be confused with *Rivulariella* are two other strictly aquatic liverworts. The most abundant, *Chiloscyphus polyanthus* (L.) Corda, is easily distinguished by its bilobed underleaves with fascicles of rhizoids originating just below the insertion of the underleaves. Only somewhat less common is *Jungermannia exsertifolia* ssp. *cordifolia* (Dum.) Vana. This may be distinguished by having cylindrical stems with only two ranks of round, unlobed leaves. Fresh material can be recognized by the presence of few, mostly two, oil-bodies in each cell in contrast to eight or more on average in median cells of *Rivulariella gemmipara.* The presence of gemmae will separate *R. gemmipara* from either common look-alike.

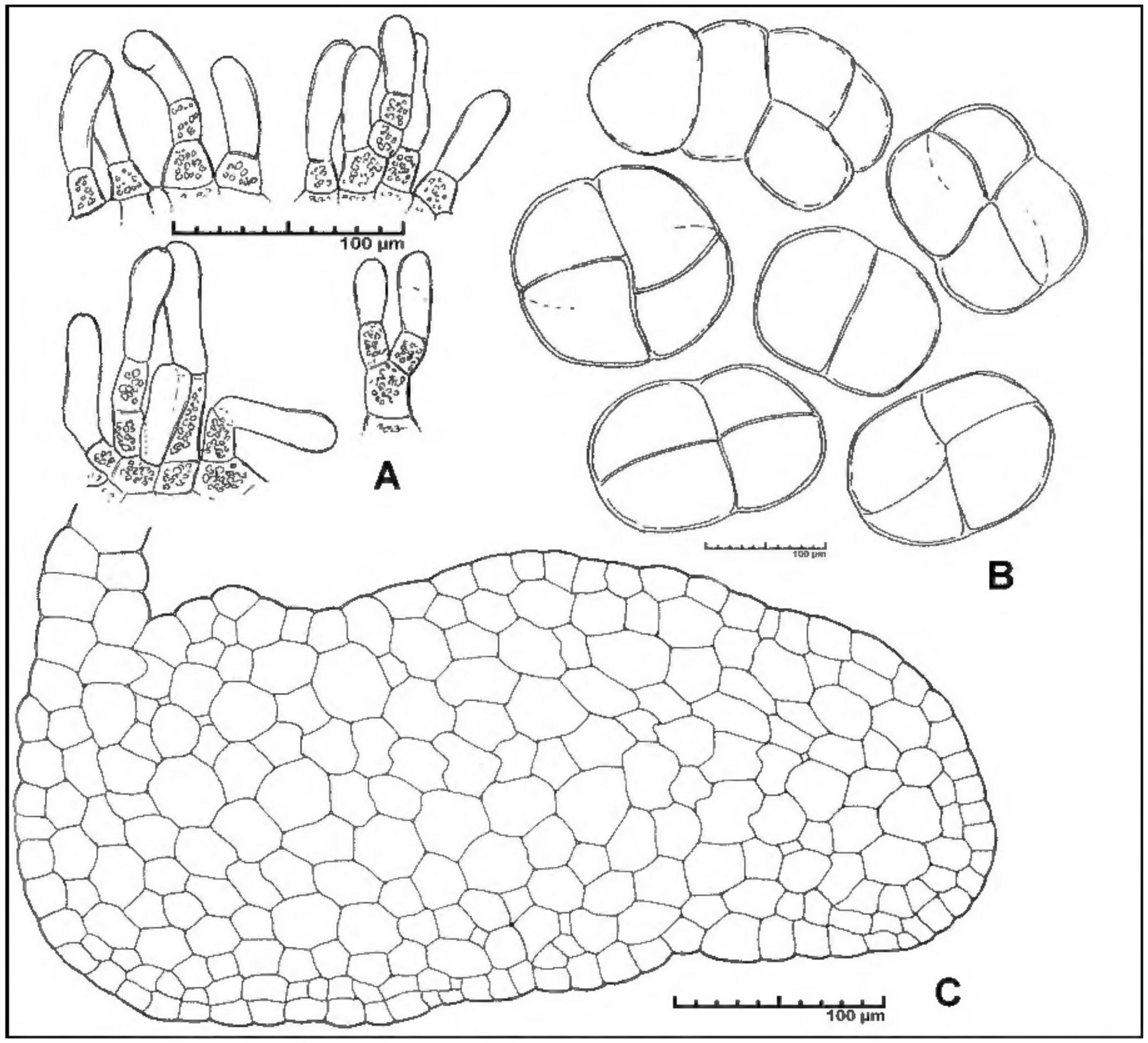

Figure 5. *Rivulariella gemmipara.* A. Typical underleaves on unattached, horizontal to ascending shoots; B. gemmae; C. cross section of stem of horizontal shoot. (A–D, *D.H. Wagner 2747*)

Ecology

Rivulariella gemmipara grows attached to rocks in moderately fast moving water. The plant is restricted to places where water flows over gravel or rocks. Where a stream has a still surface or where organic debris and muck covers the stream bed and stream sides, this liverwort will not be found. As soon as the grade of the stream breaks so that the surface of the stream is ruffled over a rocky stream bed, the liverwort may be found attached to the rocks. Rapidly moving water without rocks, however, has none of this plant. It is found only where permanent springs keep the streambed submerged at all times, and it favors sites in open areas, exposed to sun most of the day.

Other liverworts found growing with *Rivulariella* are *Jungermannia exsertifolia* subsp. *cordifolia*, *Chiloscyphus polyanthos*, and *Scapania undulata* (L.) Dum. Two lichens are also found in this association: *Peltigera hydrothyria* Miadl. & Lutzoni and *Leptogium rivale* Tuck. The ecological zone is characterized by the liverworts growing on the soil and peaty substrates forming the edge of the rivulet: *Lophozia opacifolia* Culm., *Marsupella sphacelata* (Gieseke) Dum., *Pellia endiviifolia*

subsp. *alpicola* R.M. Schust., and *Moerckia blyttii* (Moerck) Bockm. The liverworts just mentioned characterize the ecological zone as subalpine. They are always found in subalpine or alpine habitats, next to but not in running water (except that *Marsupella sphacelata* sometimes grows in intermittent water channels where it will be submerged when snow melt runoff is high). Most of the known populations of *Rivulariella* occur above 1700m.

Figure 6. Habitat of *Rivulariella gemmipara* in the Three Sisters Wilderness, Oregon.

Conservation considerations

This species, under the name *Chiloscyphus gemmiparus,* is listed as of conservation concern (Christy & Wagner 1996; Oregon Biodiversity Information Center 2010). Conservation attention seems warranted simply on the basis of its rarity. It is presently known from only twelve sites worldwide: single sites from California, Alaska, and Utah and the remainder from Oregon. Six sites are in the Three Sisters Wilderness, Oregon Cascades. Those in the wilderness area may be considered fairly well protected. Two of these have been found in stable condition upon revisiting after an interval of several years. There are three sites where attempts to search and relocate the plants have not successful: the type locality in Utah, the sole California site, and the Little Butte Creek site in Jackson County, Oregon. This species occurs in high mountain habitats that have not been thoroughly surveyed for aquatic bryophytes. It is hoped that this publication will assist in the discovery of a sufficient number of additional sites to give assurance of the continuing existence of this species without special management actions beyond periodic monitoring.

ACKNOWLEDGEMENTS

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